4.0 Program Management

The Hydrogen, Fuel Cells & Infrastructure Technologies Program supports the President's Hydrogen Fuel Initiative.

Key facets of the program management approach are:

- Structure that promotes clear lines of responsibility and accountability
- Systems integration function, focusing on overcoming barriers to success
- Performance-based planning, budgeting, execution, and program evaluation
- Cooperative partnerships

4.1 Program Management Structure

In the summer of 2001, the Administration released the President's Management Agenda, which laid out the blueprint for management improvements throughout the federal government. It called for:

- Agencies to become flatter and more responsive
- Emphasis on process to be replaced by a focus on results
- Elimination of overlapping functions, inefficiencies, and turf battles
- Strengthening of the knowledge, skills, and abilities of federal workers to meet the needs and expectations of their ultimate clients—the American people

This, in combination with the National Academy of Public Administration Report titled "A Review of Management in the Office of Energy Efficiency and Renewable Energy (EERE)" (March 2000) and the EERE Strategic Program Review (April 2002), provided the Office of EERE with findings and recommendations that assisted in the redesign of EERE's management and business model. The management structure for the Hydrogen, Fuel Cells & Infrastructure Technologies Program embodies these principles.

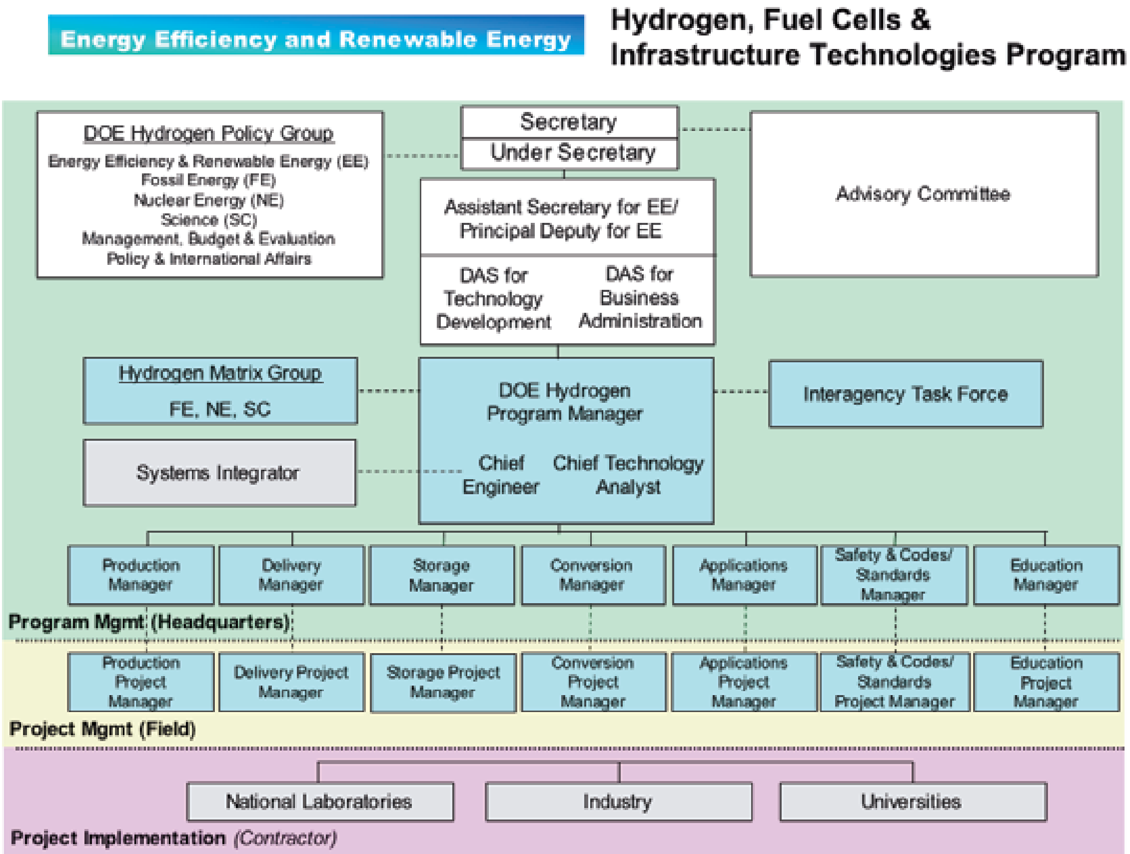
Figure 4.1.1 shows the structure for the Hydrogen, Fuel Cells & Infrastructure Technologies Program. The structure facilitates program management at DOE headquarters, project management at DOE field offices, and project implementation at the contractor level. The key features in this organization as well as the planning hierarchy for the program are described below.

DOE Headquarters - Program Management

The DOE Program Manager resides within the Office of EERE at DOE headquarters. The Program Manager has responsibility and authority for all aspects of the program. All personnel within the Office of Hydrogen, Fuel Cells & Infrastructure Technologies report directly to the Program Manager.

The Chief Engineer is responsible for integration of all seven elements of the program: production; delivery; storage; conversion; technology validation; safety; codes and standards; and education. The Chief Engineer is assisted by a Systems Integrator to ensure that requirements, costs, and schedule are controlled against an integrated baseline.

Figure 4.1.1. Organizational Chart for the Hydrogen, Fuel Cells & Infrastructure Technologies Program



The Chief Technology Analyst is responsible for independently overseeing all aspects of systems analyses. The Chief Technology Analyst, assisted by the Systems Integrator, will direct energy, environmental, and economic analyses and make recommendations to the Program Manager on critical technical, financial and policy decisions. Each of the seven program elements (i.e., production, delivery, etc.) will be led by a Technical Team Leader or a Technology Development Manager. The Technology Development Managers will be responsible for the following activities for their respective program elements:

- Planning the requirements and schedule
- Developing budget recommendations
- Overseeing execution and project implementation
- Evaluating technology development
- Providing input for responses to congressional inquiries
- Providing direction to the Golden Field Office for procurement of RD&D activities
- Providing direction and overseeing RD&D activities by the National Laboratories

Systems Integrator

The mission-oriented, systems-driven, barrier-focused approach requires a strong Systems Integration and Analysis component in the program. A systems integration function is called for in the National Hydrogen Energy Roadmap. Furthermore, the National Research Council's (NRC's) Committee studying Alternatives for Future Hydrogen Production and Use recommended that DOE establish a systems analysis function (Future Hydrogen Production and Use, Letter Report, 2003). This program function defines technical priorities based both on market needs as well as detailed trade-off analyses between system requirements and component performance and costs. This is a dynamic process. The technical priorities are adjusted to reflect new results from field validation of new components or systems. The System Integrator will carry out all analysis activities within the Program.

The National Renewable Energy Laboratory will provide the systems integration function for the program; a variety of institutions and individuals will provide analyses. The Systems Integration and Analysis functions are described in more detail in Section 4.2.

Hydrogen Matrix Group

The Hydrogen Matrix Group is composed of senior EERE Technology Development Managers for the Program and Technology Development Managers from DOE's Office of Fossil Energy (FE) and Office of Nuclear Energy Science and Technology (NE). The matrix group is shown separately in Figure 4.1.1 to emphasize the collaboration between DOE Offices at the program implementation level.

DOE Hydrogen Policy Group

There is a clear recognition for oversight from the other DOE offices. This will be accomplished through the DOE Hydrogen Policy Group that works with the Under Secretary of Energy to evaluate the effectiveness of the Program.

Advisory Committee

Expert advice from industry, academia and other key stakeholders is sought through the advisory committee, a successor to the Hydrogen Technical Advisory Panel. The committee will be composed of senior personnel from domestic industry, automakers, energy companies, suppliers, universities, professional societies, federal laboratories, financial institutions, and environmental and other organizations, as the Secretary deems appropriate. The advisory committee will review and make any necessary recommendations directly to the Secretary on:

- Implementation and conduct of programs
- Economic, technological, and environmental consequences of the deployment of technologies related to production, distribution, storage, and use of hydrogen energy, and fuel cells
- Means for resolving barriers to implementing hydrogen and fuel cell technologies

DOE Field - Project Management

A federal project manager will be designated for each of the program elements. These project managers, from the Golden Field Office, will report to the respective DOE Technology

Development Managers at headquarters and will be responsible for implementing their part of the program through industry, academia, contractors, and the National Renewable Energy Laboratory.

Project Implementation - Contractors

As depicted in Figure 4.1.1, the implementation of RD&D will be conducted "in the field" by National Laboratories, industry, and the university community. All work will be conducted in accordance with detailed Agreements between these organizations and DOE.

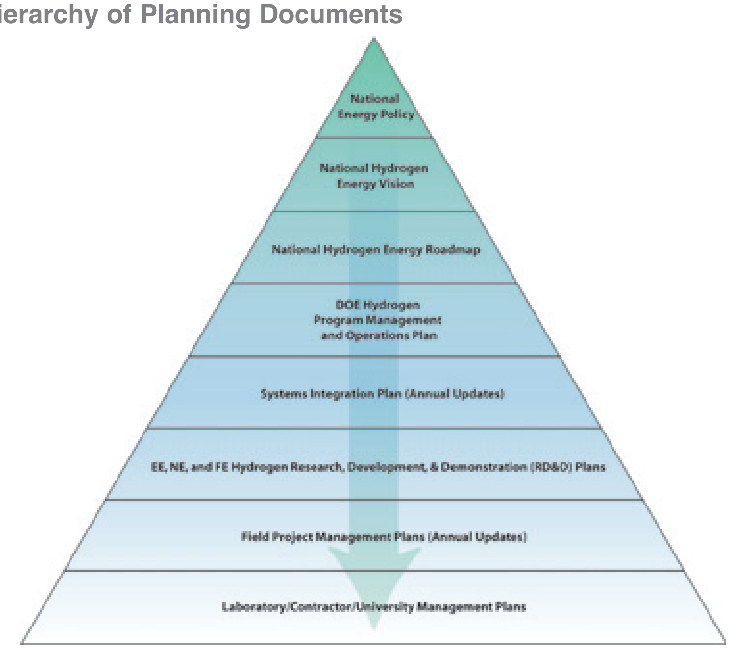
Planning Hierarchy And Document Control

Another element of program management structure is authorizing and controlling documents. The program will be conducted according to a hierarchical system of documents.

The National Energy Policy (NEP) plan directs the Secretary of Energy to "*develop next generation technology – including hydrogen …*" and to "*focus research and development efforts on integrating current programs regarding hydrogen, fuel cells, and distributed energy.*" The Department of Energy, in implementing this guidance, worked closely with a variety of stakeholders to create a "National Vision of America's Transition to a Hydrogen Economy" and then developed a "National Hydrogen Roadmap" that outlines steps necessary to reach that vision. These documents are described in the Introduction (see Section 1.0).

The three overarching documents mentioned above, along with the strategic plans of DOE and EERE, are the foundation of the planning hierarchy for the Hydrogen, Fuel Cells & Infrastructure Technologies Program. This hierarchy is based on the premise of detailed yet flexible program planning from concept development to technology validation as well as the time-phased technical, cost, and schedule plans that are essential to the efficient management of this critical program. Figure 4.1.2 shows how the planning documents relate to other DOE program plans.

Figure 4.1.2. The Hierarchy of Planning Documents



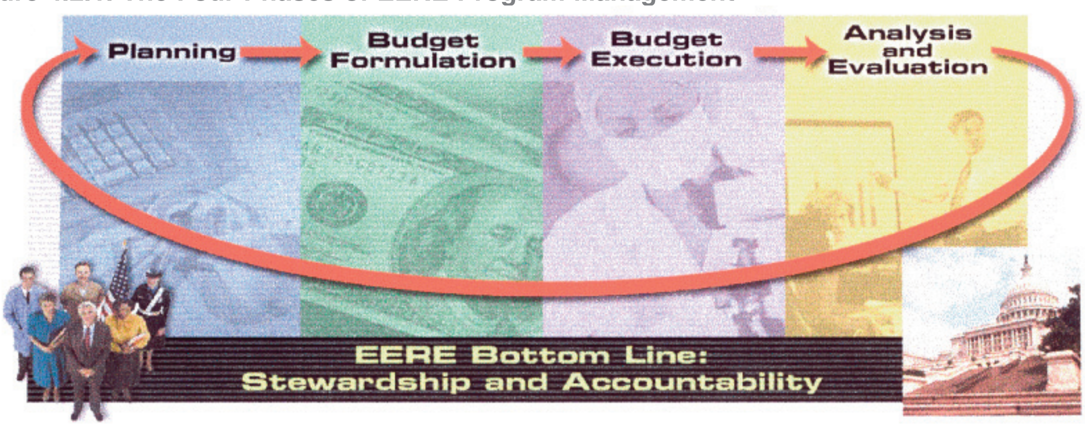
The DOE Hydrogen Program Management and Operations Plan (formerly the DOE Hydrogen Posture Plan) integrates activities across the Office of Energy Efficiency and Renewable Energy; Office of Science (SC); Office of Fossil Energy (FE); and the Office of Nuclear Energy Science and Technology (NE). Each of these DOE offices will develop its own detailed multi-year RD&D plan. This plan reflects the RD&D activities that will be pursued by the Hydrogen, Fuel Cells & Infrastructure Technologies Program within DOE's Office of EERE. The Systems Integration Plan, the Field Project Management Plans, and the Laboratory/Contractor Management Plans all address in more detail the implementation of this multi-year RD&D plan. They will be developed after this plan is finalized.

Document control is an integral part of the program management process. RD&D plans make assumptions that are sometimes market-based and at other times based on technology status. These assumptions change with time as both the technologies and market forces change. It is imperative to keep excellent documentation of these assumptions and to track changes to these assumptions over time to keep the program focused. Furthermore, program and technology development schedules that emerge from this hierarchy of plans must be well integrated and consistent – another factor that requires attention to proper document control. This effort will reside within the Program's Systems Integration function. The Chief Engineer will review all changes to the technology requirements, schedule, and cost estimates. The Program Manager has authority to approve these changes.

4.2 Performance-Based Planning, Budgeting, Execution and Evaluation

The Program will follow the EERE management system (see Figure 4.2.1).

Figure 4.2.1. The Four Phases of EERE Program Management



4.2.1 Program Planning

The National Energy Policy and EERE Strategic Plan provide the planning foundation for the Hydrogen, Fuel Cells & Infrastructure Technologies Program. The DOE Posture Plan integrates planning in the Offices of EERE; Office of Science; Office of Fossil Energy; and Office of Nuclear Energy Science and Technology. The Posture Plan, Level 1 planning, documents the major DOE activities, performance-based technology milestones, and establishes a controlled baseline cost and schedule out to 2015. See Table 4.2.1 for a description of planning levels. Throughout the year, DOE Offices will meet periodically to update their planning and review the baseline cost and schedule.

Table 4.2.1 DOE Posture Plan Planning Levels

Level	Planning
1	Integrated DOE Program Level
2	DOE Office Level
3	DOE Project Level

Detailed planning to support the posture plan will be documented in each office's Multi-Year RD&D Plan, Level 2, such as this one for EERE's Office of Hydrogen, Fuel Cells and Infrastructure Technologies. Projects supporting the program are structured according to the chapters in the National Hydrogen Energy Roadmap: Systems Integration, Hydrogen Production; Delivery; Storage; Conversion; Applications (Technology Validation); Safety, Codes and Standards; and Education. For each of these projects, an overall goal is established and time-phased, performance-based objectives and technology targets have been established to address the critical technology barriers. This plan then identifies the time-based schedule task, Level 3, out to the year 2010 to meet the time-phased objectives.

4.2.2 Program Budgeting

The budget falls under the jurisdiction of two separate appropriations subcommittees:

- Energy and Water Development for the *Hydrogen Technology* subprogram which includes key activities in:
  - Hydrogen Production and Delivery
  - Hydrogen Storage
  - Hydrogen Infrastructure Validation
  - Safety, Codes and Standards
  - Education and Cross-Cutting Analyses
- Interior and Related Agencies for the *Fuel Cell Technology* Subprogram which includes key activities:
  - Transportation Systems
  - Distributed Generation Systems
  - Components
  - Fuel Processing
  - Technology Validation

As described in this Plan, resources appropriated in Infrastructure Validation under the Hydrogen Technology subprogram and Technology Validation under the Fuel Cell Technology subprogram, are planned, executed, and evaluated as one project. All key activities support System Integration function.

Program budget performance is regularly evaluated by the Office of EERE through regular management reviews and the Annual Budget Summit. In addition, the Office of Management and Budget (OMB), in consultation with Office of Science and Technology Policy, evaluate the Program budget performance annually from September through November prior to each new fiscal year. Each year, the Program reports the current status against pre-established Program Strategic Performance Goals (PSPG's) which reflect the time-phased, performance-based objectives identified for each project. Budget resources are requested from Congress based on a number of factors. Foremost, is that, within each project area (Production, Delivery, etc.) the activities must fall within the DOE, EERE, and Program mission and not another program or agency. Furthermore, it must be an activity that industry is not funding or would not fund by itself (e.g., codes and standards coordination, safety data, long-term R&D). An example of an area the Program no longer funds is fuel cell stack engineering. Since industry developed this capability in the early to mid 1990's with DOE assistance, it is no longer a high risk technology requiring government funding. At the time of this writing the following shows the Program's budget priorities:

Key Activities in Congressional Budget Request

1. Hydrogen Storage
2. Hydrogen Production and Delivery
3. Fuel Cell Component Research
4. Safety, Codes and Standards
5. Infrastructure and Technology Validation
6. Education and Cross-cutting Analysis
7. Fuel Processing Research (Fuel Cells)
8. Distributed Generation Systems
9. Transportation Systems

4.2.3 Program Execution

Within each of the key activities or project area (i.e. production, delivery, etc.) the tasks identified to overcome the barriers are discreetly executed by an industry contractor, national laboratory, or university. Within each area, tasks are prioritized by analyzing the "current" in this case "2003 status" against the out year targets. In the hydrogen fuel cell example shown in Table 4.2.2, "Durability" is identified as a critical barrier and therefore a priority task. Power density would be a moderate priority. Based on the development success with prior DOE funding, the energy efficiency task would be a very low priority since the 2005/2010 targets are nearly met. It should be noted that all targets must be met simultaneously for the technology development to be declared successful. Therefore, trade-offs between these targets will occur and they cannot be evaluated separately. This is the vital role of the Technology and Infrastructure Validation project, in which the technology development is evaluated in a systems context. Based on results of the validation or demonstration project, the R&D is re-focused or re-directed.

Table 4.2.2. Example of Targets for Hydrogen Fuel Cells

	2003 Status	2005	2010	Analysis
Energy Efficiency @25% power	59	60	60	Very close to target
Power Density (w/L)	400	500	650	40% improvement required
Durability (hours)	1,000	2,000	5,000	500 factor improvement required

University research is awarded through competitive solicitations. Since this work is more fundamental in nature, the federal cost share can be as high as 80%.

Industry contracted research is also awarded through competitive solicitations. Depending on the risk, the Federal cost share is usually between 50% and 80%. Technology validation or demonstration projects typically are split 50:50 between government and industry. The technology targets from this plan are used to establish performance-based deliverables for solicitations directed at university and industry contractors.

Each contractor/university Work Plan or national laboratory Annual Operating Plan will have a schedule of interim technology targets that support the multi-year targets and program objectives and that can be evaluated on a periodic basis.

4.2.4 Program Analysis and Evaluation

Program analyses are discussed in Section 4.3, System Integration. Evaluation is conducted at the Program level and the Project level. Peer reviews conducted by the National Research Council (NRC), or an equivalent independent group will be carried out every two years. This RD&D Plan is currently undergoing NRC review. The advisory committee will also review the Program at semi-annual meetings and provide an assessment and recommendation directly to the Secretary of Energy. Program budget performance, financial management, and overall program management is evaluated on a periodic basis by EERE management.

Tasks performed by industry, universities, and national laboratories are evaluated annually at the Program Merit Review and Peer Evaluation meeting. An independent review panel reviews all tasks supporting each Project in accordance with criteria (See Appendix D for sample evaluation sheets and criteria).

DOE Technology Managers usually perform an additional "mid-year" review of national laboratory tasks. Larger industry tasks which include significant resources or hardware development are also reviewed an additional 1-2 times per year. Following the Annual Merit Review and Peer Evaluation, typically conducted in May, the Program Technology Development Managers analyze the results over the summer and make their funding decisions regarding each task prior to the new fiscal year. Each year the Program will publish the results and decisions from the Annual Merit Review and Peer Evaluation.

In addition, every December, the Program publishes an Annual Report which documents the data and progress achieved by project. The Executive Summary of the Annual Report will include an assessment by the Program Manager on the major accomplishments made and challenges identified over the last year. The abstract for each task will include a reference to the project and barrier identified in this RD&D Plan.

4.3 Systems Integration

The Hydrogen, Fuel Cells & Infrastructure Technologies Program will implement a robust systems integration function that provides a solid foundation for a results-driven program approach consistent with the President's Management Agenda. Establishing this approach acknowledges the need to manage the complex interactions between interrelated technical and programmatic elements so that program objectives can be accomplished in the most cost-effective manner through ongoing evaluation of performance, cost, schedule, and risk. Unlike systems integration applied in other environments, such as the National Aeronautics and Space Administration or the Department of Defense, in which the government is the customer for the system to be delivered and therefore has full control over system requirements, the Hydrogen, Fuel Cells & Infrastructure Technologies Program must manage a dynamic system in which the requirements are established by the ever-changing marketplace.

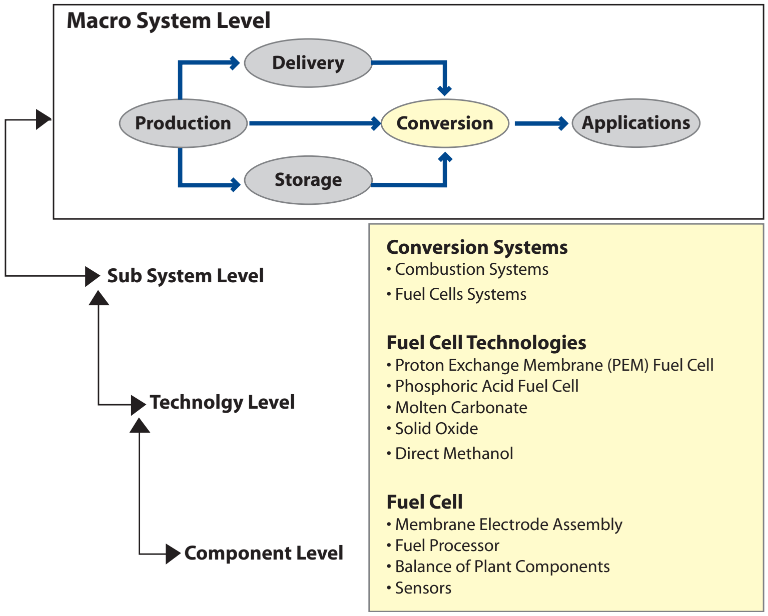
The mission of the systems integration function is:

> ***Systems Integration will deliver independent and objective analyses, advice, and planning options that enable the DOE Program Manager to make informed decisions that result in successful technology development and validation, and enable a positive commercialization decision in 2015.***

4.3.1 The System

The complex interdependencies of the project activities (production, storage, delivery, conversion, and applications, codes and standards, safety, and education) need to be understood and the interfaces managed in order to appropriately integrate and align individual efforts in relationship to overall objectives at the macro-system level. Figure 4.3.1 shows an example of how one element of the program, conversion, breaks down into its subsystem, technology, and component levels. At each level below the macro-system level, technical targets are established in the context of requirements that flow from the next higher level, and progress is monitored with respect to those targets as well as to how new information arising from individual projects may affect other elements within the macro-system. The systems integration function will work very closely and collaboratively with the Chief Engineer, Chief Technology Analyst, and Program Management in order to delineate, model, and analyze all the potential macro-system pathways from hydrogen production to application.

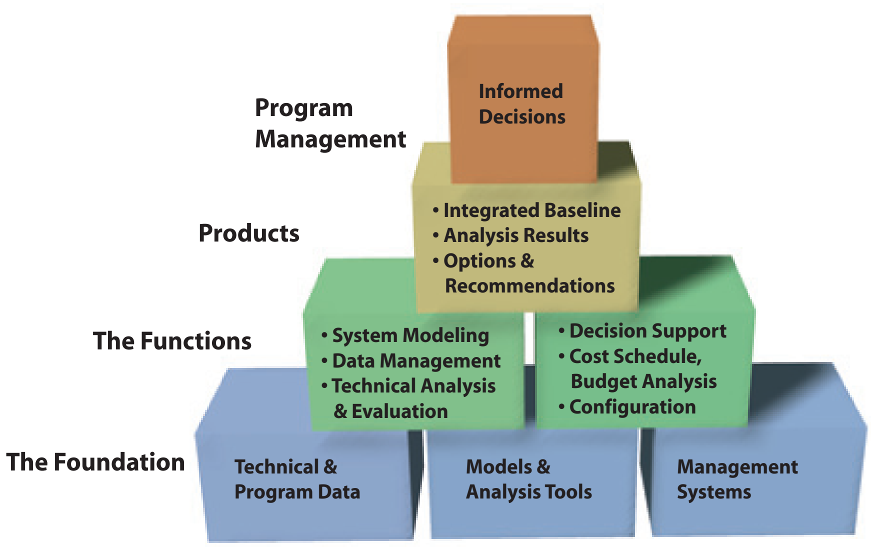
Figure 4.3.1. The Hydrogen Energy System



4.3.2 Systems Integration Framework

The core function of systems integration is to establish, validate, and maintain the integrated baseline. In order to accomplish this function, the systems integrator needs to: 1) establish and implement the management tools that enable gathering, developing, and analyzing data and information across and between each the levels, 2) conduct analyses, planning, and evaluations, and 3) interpret the results in executive level products that identify issues and opportunities and provide well-analyzed options and recommendations. These will provide a strong and credible basis for program management decisions. These three core functions and their relationship to program management are shown in Figure 4.3.2 and are described below.

Figure 4.3.2. Systems Integration Framework



4.3.2.1 The Foundation

The systems integration function will provide the 'glue' to help integrate the program horizontally across participating organizations and vertically from the macro-system to the component level. The system integration function rests on a strong foundation of tools that enable collecting and organizing technical information to enable successful planning and executing of the program as well as individual projects in the context of the macro-system. These tools support capturing the results of individual efforts, reviewing progress against stated objectives, and conducting ongoing evaluations that help organize and align individual efforts to contribute to advancing the program objectives.

Technical and Program Data

Analyses, recommendations, and decisions will be made on a sound foundation of technical and programmatic data. These data will be obtained and managed in a secure information technology system by the Systems Integrator. A technical data management system will contain consistent data and information standards and tools for capturing and making needed information available within and across levels of the systems and between functions. The architecture for this system establishes the protocols for access to various kinds of information while protecting information that needs to be restricted to certain users. Protocols for access and use will be established and agreed to by appropriate organizations with the public-private partnerships.

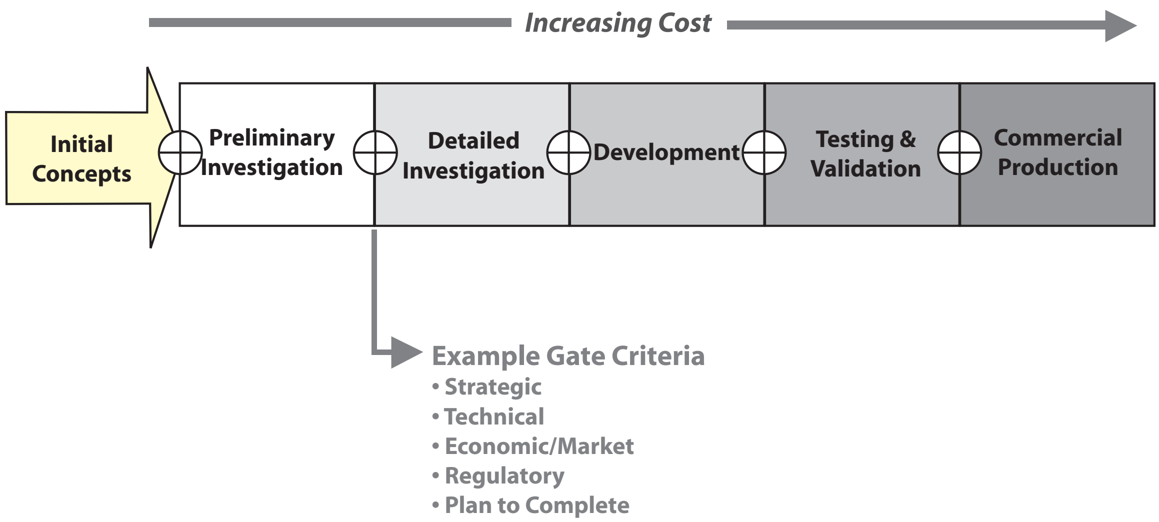
Models and Analysis Tools

The systems integration function will delineate and model all the potential macro-system pathways from hydrogen production to application. The modeling system provides the basis for analyzing alternatives at the system, technology, or component level in terms of their cost, performance, benefit and risk impact on the macro-system. Establishing and effectively using the macro-model to conduct trade-off analyses requires that credible and consistent data and information be available from project performers and from individual analytical efforts. In addition, the macro-system model must constantly be updated to address the changing market and policy environment. Definition of the requirements for the macro-system model will be defined by a wide-ranging group of people with expertise in all aspects of the political, economic, and technical aspects of the system. Through various partnerships and focused workshops, experts will advise the System Integrator on requirements for the macro-system model. The macro-system model will be a modeling system composed of several component models. The best expertise in the country will be used for modeling.

Management Systems

The management systems encompass the hardware, software, and protocols for accessing information and reporting. Program integration establishes consistent protocols for reporting status that enable evaluating the impact of individual project efforts on the overall progress of the program against technical targets and against the master schedule. The system provides the data and tools that enable identifying and conducting critical path analyses. Along with a clear understanding of the program baseline (i.e., program plan), there is a need for evaluating technical and program options. A systematic decision process based on sound analytics and consistent project evaluation standards will provide a credible and transparent basis for key program decisions. A stage-gate process will be used to manage investments in development projects. The stage-gate process (represented conceptually in Figure 4.3.3) is a disciplined approach for evaluating projects at key points (gates). For the President's Hydrogen Fuel Initiative, this decision framework will account for evolving markets and government policies.

Figure 4.3.3. Stage-Gate Decision Process



At the beginning of each stage is a gate, or a decision point, that must be passed before work on the next stage can begin. Reviews held at these key stages ensure that a project has met its objectives and that the plan for proceeding will satisfy the criteria for the next gate. Reviewers may include government, national laboratory, and private sector individuals.

The general types of criteria used at each stage are shown in the figure, with the specific criteria becoming more rigorous as the project advances toward commercialization. At each gate, decisions are made to either:

- Advance the project to the next stage
- Continue the current effort because not all goals have been met
- Place the project on hold because the need appears to have gone away, but could re-emerge
- Stop the project because it is unlikely to meet its goals or the need for the effort has permanently disappeared.

Each of the gate reviews are conducted in the context of changing external conditions, with consideration of new knowledge and insights that are gained within the program (at any level), and with a focus on the impact of decisions on overall program outcomes.

4.3.2.2 The Functions

The Systems Integrator will support the Chief Engineer in monitoring each of the projects with respect to the subsystem components that are critical to the overall success, performance, and attributes of the hydrogen macro-system. The various potential technology pathways, on a macro-system basis, will be modeled and analyzed from the standpoints of established application requirements (targets), costs, risks, environmental impacts, and societal impacts; plus, key cost and technology barriers/gaps will be identified. These results will help to further define and update the key RD&D needs and plans within each of the projects. In addition, the Chief Technology Analyst will use these results to update assumptions for energy, environmental, and financial impact/risk projections.

From an overall programmatic perspective, the Systems Integrator will enable the Program to integrate program and project planning; budgeting; assignment of requirements, milestones, and schedules; and performance monitoring and reporting.

System Modeling, Data Management, Technical Analysis and Evaluation

Core activities include system modeling, data management, and technical analysis & evaluation. The Systems Integrator will receive information from all portions of the initiative to perform integrated technical evaluations. These evaluations will be conducted within the context of the macro-system, and they will span subsystems appropriate for the specific evaluation underway. Results from the technical evaluations will be communicated to the Program Manager and technology development managers on an ongoing basis.

Decision Support, Cost, Schedule, Budget Analysis, and Configuration Control

The systems integration function will establish a schedule for work that will lead to achievement of the technology development goals of the initiative in 2015. The network of activities will link all activities within the macro-system of hydrogen energy and fuel cells. Progress on attainment of objectives and adherence to schedule will be monitored on an ongoing basis.

Linked to the schedule will be a cost plan. Costs of completed work as well as estimates of cost-to-completion will be analyzed continuously and reported to the Program Manager. This information will enable DOE to measure budget performance and to formulate and justify budget requests.

A critical element of the systems integration function is configuration control. The Systems Integrator will develop a system for maintaining configuration control in order to document the basis for all analyses and recommendations and to ensure their integrity in terms of a trail of information leading back to the data and results upon which recommendations and decisions are made. The Program Manager will have change control authority.

4.3.2.3 Products

The primary products from the systems integration function can be described as (1) an integrated baseline (i.e., controlled parameters) (2) analysis results, and (3) provision of options and recommendations. These products will be provided to the Chief Engineer, Chief Technology Analyst, and Program Manager for their use in programmatic decision-making.

Integrated Baseline

A key product that will be developed in FY 2004 will be an integrated baseline. The integrated baseline contains two major components: the technical baseline and the programmatic baseline.

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The technical baseline describes the system performance requirements that must be met to achieve the goal of the President's Hydrogen Fuel Initiative. For DOE's program these are the technical goals, which specify functional performance and costs of components and systems. These technical goals build to conform to the program objectives, which are referred to as strategic performance goals (PSPGs) in the Federal budget request.

The programmatic baseline contains information on the projected costs associated with each work element, and the interdependency of schedule of activities. Costs and schedules are controlled against the technical baseline goals of the program. Thus these two components of the baseline will be integrated, i.e., linked, to provide a program plan that can be relied upon.

Analysis Results and Recommendations

Over the course of the President's Hydrogen Fuel Initiative, the Systems Integrator will continually analyze the current state of technical progress, costs incurred and planned, and schedule against the baseline. Analysis results will be reported to the Chief Engineer, Chief Technology Analyst, and Program Manager on a regular basis for scheduled analyses as well as on an ad hoc basis in response to requests by the DOE Program Manager. In addition, providing the Program Manager with sets of options and recommendations for action will be a principal product from the systems integration function.

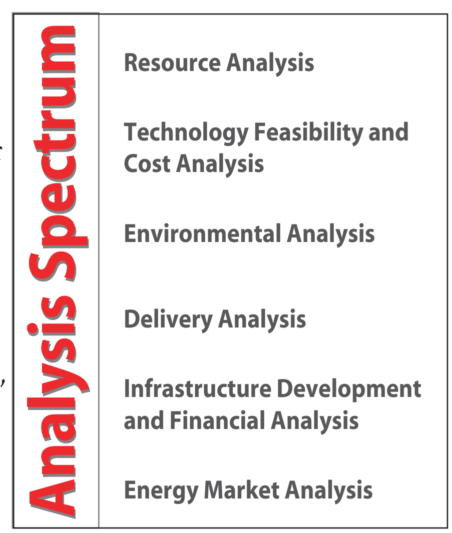
These results and recommendations will be used by the Program Manager to identify issues and opportunities for the Hydrogen, Fuel Cells & Infrastructure Technologies Program. The issues may encompass technical, schedule, and budget matters, which themselves will interact with each other. In addition, issues may arise within the President's Hydrogen Fuel Initiative or they arise from forces outside of the initiative. The opportunities will allow DOE's Program Manager to direct the course of work along specific paths. The systems integration function will have sufficient technical knowledge of hydrogen energy and fuel cells to provide a firm basis for identifying opportunities to accelerate, redirect, or conclude work on portions of the initiative. Opportunities for collaboration with other worldwide activities will also present themselves; they will be analyzed within the context of systems integration.

4.3.3 Analysis

The Systems Integrator uses integrated analyses to support Program decision-making by providing greater understanding of (1) the contribution of individual elements of a complete hydrogen energy system to the whole, and (2) the interaction of various elements and their effects on the system. Analysis activities provide direction, focus, and support to the development and introduction of hydrogen production, storage, and end-use technologies, and provide a basis for recommendations on a balanced portfolio of activities. Analysis is conducted to support the Chief Technology Analyst, and also as part of the Program elements of production, delivery, storage, fuel cells, technology validation, safety, and codes and standards.

Figure 4.3.1 shows the types of analyses that are used in the Program. Used in combination, these analysis

Figure 4.3.1. A Spectrum of Analyses



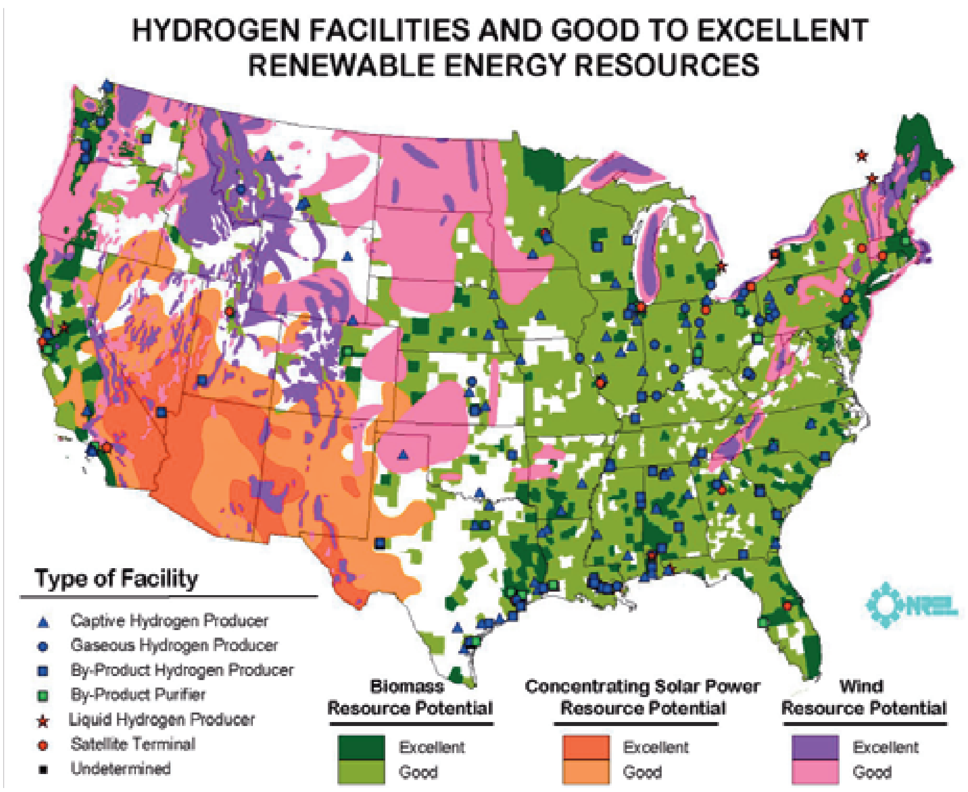
methodologies can provide a sound understanding of the Program elements and developing markets. A key function of the Systems Integrator will be to utilize results from each of these methodologies to provide information and recommendations to the Program. In general, each methodology builds on previous efforts in the analysis spectrum, to quantify the benefits, drawbacks, and risks of different hydrogen development scenarios. Results from each area of the analysis spectrum will be used as inputs to the stage gate process described earlier.

Realistic assumptions, both market-based as well as technology-based, are critical to an accurate analytical study. In long-term research and development programs, assumptions change due to advances in technology and changes in the marketplace. The Systems Integrator ensures that all the assumptions used in the analysis are well documented and updated regularly to reflect the dynamic nature of a robust RD&D program.

Analysis Methodologies – The Analysis Spectrum

Resource Analysis determines the quantity and location of resources needed to produce hydrogen. Additionally, resource analysis quantifies the cost of the resources, as a function of the amount that can be available for hydrogen production. While often associated with renewable resources, resource analysis is also suitable for fossil resources and existing production facilities. Geographic Information Systems (GIS) modeling is often used to portray and analyze resource data. GIS can also represent the spatial relationship between resources, production facilities, transportation infrastructures, and hydrogen demand centers. An example of a GIS map is given in Figure 4.3.2.

Figure 4.3.2. An Example of Resource Analysis to Guide the Investment on Renewable Production Technologies



Technology Feasibility and Cost Analysis is performed to determine the potential economic viability of a process or technology, and helps to identify which technologies have the greatest likelihood of economic success. Results from technology feasibility analysis efforts provide input to balanced portfolio development and technology validation plans. The economic competitiveness of a technology is assessed by evaluating its implementation costs for a given process compared to the costs incurred by current technology. These analyses are therefore useful in determining which projects have the highest potential for near-, mid-, and long-term success. Parameters studied include production volume benefits, economies of scale, process configuration, materials, and resource requirements. Of principle importance, technology feasibility analyses can help direct research toward areas in which improvements will result in the largest cost reductions. Additionally, advancement toward the final goal of commercialization can be measured as the economics of a process are evaluated throughout the life of the project. Tools used for technology feasibility analysis include process modeling (e.g., ASPEN Plus©), equipment cost modeling, and cash flow analysis. Technology feasibility analysis is performed on a regular and ongoing basis, in the areas of delivery, storage, and fuel cells.

Environmental Analysis is used by the Program to quantify the environmental impacts of hydrogen technologies. Specifically, life cycle assessment is used to identify and evaluate the emissions, resource consumption, and energy use of all processes required to make the process of interest operate, including raw material extraction, transportation, processing, and final disposal of all products and by-products. Also known as cradle-to-grave or well-to-wheels analysis, this methodology is used to better understand the full impacts of existing and developing technologies, such that efforts can be focused on mitigating negative effects. A suite of environmental analyses on major production systems, delivery options, and use will be conducted through 2005.

Delivery Analysis identifies the most economic options for delivering hydrogen, and provides a foundation for additional research on alternative storage and transportation options. Additionally, delivery analysis provides crucial information to technology feasibility analysis, in determining the optimal production capacities and locations. Delivery analyses will be conducted to determine the most promising technologies, as inputs to other technical elements of the Program. One planned study will evaluate and compare the respective benefits of transmitting energy from distributed resources as electricity over existing or expanded grid infrastructures, as hydrogen via pipeline, or as a liquid energy carrier to point-of-need reformers.

Infrastructure Development and Financial Analysis quantifies the total costs of scenarios for developing the hydrogen infrastructure, including production, delivery, and utilization. By combining the results of previous analyses in the analysis spectrum, infrastructure development analysis can identify economical routes and financial risks for providing the lowest delivered cost of hydrogen from combinations of central and distributed production facilities. Evaluations of the costs, impacts on existing infrastructures, and timelines of various scenarios for the development of a hydrogen infrastructure will be conducted through 2005.

Energy Market Analysis synthesizes all analysis efforts in the analysis spectrum. Scenario analyses, in the context of market analysis, are used to answer several questions:

- What are the feasible options for developing a future in which hydrogen plays a role?
- What are the impacts, costs, and financial risks of the various scenarios for transitioning to the hydrogen future?
- Which technologies are most likely to be a part of the hydrogen future, and what are the interactions between these technologies and other energy sources and carriers?
- What market penetration pathways are likely?
- What are the scenarios for hydrogen use in transportation and stationary markets?

The scenarios that are developed and the costs and benefits that are quantified, are used to develop a broad understanding of the most viable routes for achieving the hydrogen future. Results are useful in crosscutting benefits analysis, and will be used by the Systems Integrator to provide decision-making recommendations to the Program. Studies will be carried out to evaluate the opportunities for intermittent renewables, including cost, location, benefits of grid interaction, and areas for enhanced RD&D. Additionally, all the analysis capabilities described in the analysis spectrum will be synthesized into energy market analysis models to develop a broad capability for analyzing the development of possible hydrogen futures.

4.4 Public-Private Partnerships

The Hydrogen, Fuel Cells & Infrastructure Technologies Program is leveraging the vast capabilities and experience of its stakeholders through cooperative partnerships. Figure 4.4.1 graphically illustrates the major stakeholders that the program is coordinating and collaborating with to implement the President's FreedomCAR and Hydrogen Fuel Initiative.

The roles of stakeholder groups vary, as does the nature of their collaboration with DOE. In broad terms the roles that these stakeholder groups play are:

- **Federal Agencies**: Partnerships in research and development, safety, codes and standards, environmental and regulatory issues.
- **State and Local Governments**: Partnerships in codes and standards, field validation, and education.
- **Industry**: Partnerships in developing, validating and deploying advanced fuel cell and hydrogen energy technologies.
- **International**; Partnerships in research and development, validation, codes and standards and safety.

Figure 4.4.1. Major Stakeholders

The National Energy Policy (2001) recommends for research and development programs on both energy efficiency and renewable energy, and alternative energy that ***"the Secretary of Energy propose appropriate funding of those research and development programs that are performance-based and are modeled as public-private partnerships."***

4.4.1 Interagency Task Force

The task force includes:

- Office of Science and Technology Policy (lead)
- Department of Energy
- Department of Transportation
- Department of Defense
- Department of Commerce (including the National Institute for Standards and Technology)
- Environmental Protection Agency
- National Aeronautics and Space Administration

- Department of State
- U.S. Department of Agriculture

The task force will prepare and implement a comprehensive coordination plan for federal hydrogen and fuel cell energy activities. Together agencies have ongoing work across all aspects of the President's FreedomCAR and Fuel Initiative and the Hydrogen, Fuel Cells & Infrastructure Technologies Program (see Table 4.4.1).

Table 4.4.1. The Interagency Coordinating Team Will Coordinate Activities Across All Elements of Hydrogen Technologies

Interagency Coordinating Team and Key Contributions								
Agency	Production	Delivery	Storage	Conversion	Technology Validation	Safety	Codes & Standards	Education
Office of Science and Technology Policy								
Energy	X	x	x	x	x	x	x	x
Transportation		x			x	x	x	
Commerce					x	x	x	
State	X	x						
Environmental Protection Agency					x		x	x
National Aeronautics and Space Administration		x	x	x		x	x	

4.4.2 State and Local Government

The California Fuel Cell Partnership is a unique collaborative of auto manufacturers, energy companies, fuel cell technology companies, and government agencies. This partnership* is advancing a new vehicle technology that could move the world toward practical and affordable environmental solutions. The California Fuel Cell Partnership is a path breaking collaboration of auto companies, fuel providers, fuel cell technology companies and government agencies that is placing fuel cell electric vehicles on the road in California. The partnership includes the California Air Resources Board, the California Energy Commission, the South Coast Air Quality Management District, the U.S. Department of Energy, the U.S. Department of Transportation and the U.S. Environmental Protection Agency.

The Program has established State Energy Projects (SEP) Fuel Cell Demonstration & Coordinated Public Education Activities Projects. This SEP offers funding to States in collaboration with colleges and universities for projects that showcase transportation and stationary fuel cell technologies and incorporate activities to educate the local community. In addition, states are eligible to team with private entities to respond to Program research and demonstration projects. The Hydrogen Vehicle Fleet and Infrastructure Technology Validation and Demonstration Project is and example where state governments can co-sponsor, with DOE, and industry teams.

The Regional Offices of DOE's Office of Energy Efficiency and Renewable Energy (EERE) catalyze the implementation of energy-efficient and renewable energy strategies at the state and local level by:
• Working with states and communities to promote EERE programs
• Identifying and engaging community and state partners
• Integrating EERE programs with public and private sector activities.

The state and local partnerships that take place through the Regional Offices are the primary vehicle through which the Department of Energy meets the needs of individual citizens, cities, counties, and states across the nation. Through the EERE Regional Support Offices, the Program will sponsor technology workshops and informational meetings.

4.4.3 International

On April 23, 2003, Secretary Abraham called for an "International Partnership for a Hydrogen Economy." As a result of the Secretary's vision, efforts have been initiated with the European Commission in the areas of codes and standards, polymer fuel cells, hydrogen production, hydrogen storage, and economic modeling. It is anticipated that areas such as codes and standards be expanded to other global partners.

> ***"International cooperation is key to achieving hydrogen and fuel cell program goals such as those President Bush stated in his recent State of the Union address," Secretary Abraham said. "Partnerships that leverage scarce resources, develop technology standards, and foster private-public technology and infrastructure collaboration can more easily overcome the technological and institutional barriers that inhibit the development of a cost-competitive, standardized, widely accessible and safe hydrogen economy."***
> – Secretary Spencer Abraham, April 2003

The Secretary's call for an International Partnership will build on the efforts of the last several years in which DOE has coordinated activities involving the European Union and the International Energy Agency (including Japan, Europe, and Canada) to advance hydrogen and fuel cell technologies. The Program is taking leadership in the International Energy Agency Hydrogen Implementing Agreement and Advanced Fuel Cell Implementing Agreement (see Table 4.4.2).

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Table 4.4.2 International Energy Agency Hydrogen and Advanced Fuel Cell Agreement Tasks

Hydrogen	Fuel Cells
Photoelectrolytic Production of Hydrogen Photobiological Production of Hydrogen Hydrogen from Carbon Containing Materials (Biomass and Natural Gas) Solid and Liquid State Hydrogen Storage Materials Integrated Systems: Demonstration Project Evaluation	Fuel Cells for Stationary Applications Solid Oxide Fuel Cells Molten Carbonate Fuel Cells Towards Demonstration Fuel Cells for Transportation

In addition, the Program is working with international groups, such as the International Code Council and the International Standards Organization to develop a comprehensive set of codes and standards, which will facilitate the global demonstration and commercialization of hydrogen and fuel cell technologies.

4.5 Plan Development and Updates

This plan outlines the strategy to provide the technology capable of developing abundant, reliable, affordable, and environmentally sound energy supplies. The targets and milestones outlined have been developed in close collaboration with laboratory, university and industry experts, and were reviewed by the National Research Council's (NRC's) Committee on Alternatives and Strategies for Future Hydrogen Production and Use. This is a living document that will be updated and expanded frequently[1] to reflect the maturing of technologies and the identification of new approaches.

[1] Major revisions are not expected more than once every two years.